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Involvement of Polyhydroxyalkanoates in Stress Resistance of Microbial Cells: Biotechnological Consequences and Applications

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Polyhydroxyalkanoates (PHA) are polyesters accumulated by numerous prokaryotes as storage materials; they attract attention as "green" alternatives to petrochemical plastics. Recent research has demonstrated that their biological role goes beyong their storage function, since they presence in cytoplasm enhances stress resistance of microorganisms. To address these complex functions, this review summarizes the protective effects of PHA for microrganisms; the involvement of PHA in stress resistance is discussed also from a praxis-oriented perspective. The review discourses the controlled application of stress to improve PHA productivity. Also the manifold advantages of using stress adapted microbes - extremophiles as PHA producers are discussed.

Keywords: polyhydroxyalkanoates; bacteria; *Archaea*; stress conditions; stress survival; bioremediation; bacterial inoculants; biotechnological production of polyhydroxyalkanoates; extremophiles; mixed microbial cultures

1. Introduction

In 1926, Lemoigne demonstrated that *Bacillus megaterium* accumulates granules of poly(3-hydroxybutyrate) (P(3HB)), the homopolyester of 3-hydroxybuyric acid (3HB). Since this first report, the production and accumulation of polyesters of various hydroxy acids, so-called polyhydroxyalkanoates (PHA), has been reported for numerous prokaryotes (Steinbüchel and Hein, 2001). Despite the fact that P(3HB) constitutes the most common and best-studied member of the PHA family, various microorganisms can produce differently composed PHA co- and terpolymers, characterized by different lengths of the monomer's side chains and/or backbones. The general chemical structure of PHA polyesters is provided in Figure 1. Polymers containing monomer units with 3–5 carbon atoms are referred to as short-chain-length PHA (scl-PHA), whereas medium-chain-length PHA (mcl-PHA) consist of monomer units with 6–14 carbon atoms. Microorganisms accumulate PHA in the form of intracellular granules, which primarily serve as storage of carbon and energy. PHA granules are typically biosynthesized when a carbon substrate is present in excess in parallel to